

**FINAL REPORT**

**HYDROLOGIC ASSESSMENT OF  
THE WINLAW OPERATING AREA  
FOREST DEVELOPMENT PLAN  
(AMENDMENT #9)**

*Prepared for:*

**BC Timber Sales**  
Kootenay Business Area  
1907 Ridgewood Road  
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V1L 6K1

*Prepared by:*

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**Project 559-31.01**

**July 2004**



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Ms. Sandi Best, R.P.F.  
Planning Forester  
BC Timber Sales  
Kootenay Business Area  
1907 Ridgewood Road  
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Dear Ms. Best:

**Re: Hydrologic Assessment of the Winlaw Operating Area Forest Development Plan  
(Amendment #9)**

Summit Environmental Consultants Ltd. (Summit) is pleased to provide you a final report on the above-noted study. This report addresses Service item #2 in Schedule A of Contract PD2005TKOKO020 (ECA's and IWAP Update, Trozzo and Pedro Creeks). The results of the study indicate that the current FDP is consistent with the recommendations of the current IWAPs, and that the risks associated with the FDP are low to moderate in the Trozzo Creek, Winlaw Creek, and Pedro Creek watersheds. Recommendations are provided for moderate risk areas. In addition, we have provided a comparative summary of the hydrologic impacts of harvesting and not harvesting beetle-infested trees.

Please call me if you have any questions.

Yours truly,

**Summit Environmental Consultants Ltd.**

Brian T. Guy, Ph.D., P.Geo., P.H.  
Senior Geoscientist

Attachments: Final Report

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## 1.0 INTRODUCTION

This report presents the results of a hydrologic evaluation of the current Forest Development Plan (FDP) for the Winlaw Operating Area (Amendment #9)<sup>1</sup>. The objectives of the report are to:

- 1) comment on the consistency of the amended FDP with current IWAP recommendations for Trozzo, Winlaw, and Pedro Creeks;
- 2) comment on the impacts of harvesting beetle-infested trees;
- 3) comment on the likelihood of impacts on domestic water supplies; and
- 4) prepare a risk analysis of the overall proposal.

## 2.0 METHODS

This report was completed on the basis of an office-based review of the current FDP (Amendment #9), recent hydrologic assessments completed for the Trozzo, Winlaw, and Pedro Creek watersheds (completed in 1998 and 1999), recent terrain stability field assessments (Sitkum, 2004a and b), and scientific literature in forest hydrology specifically related to insect-infested trees. No field work was conducted in the preparation of this report.

## 3.0 CONSISTENCY OF AMENDED FDP WITH CURRENT WATERSHED ASSESSMENT RECOMMENDATIONS

### 3.1 TROZZO CREEK

The current FDP for the Winlaw Operating Area (Amendment #9) is consistent with each of the planning recommendations of the current IWAP (Summit, 1998a) for Trozzo Creek:

---

<sup>1</sup> This report addresses Service item #2 in Schedule A of Contract PD2005TKOKO020 (ECAs and IWAP Update, Trozzo and Pedro Creeks). The remaining items of the contract will be addressed under separate cover.

- equivalent clearcut area (ECA) should not exceed 30% in the Upper Trozzo sub-basin, 25% in the South Trozzo sub-basin, and 30% in the Residual sub-basin before another hydrologic evaluation is completed;
- the total area of proposed development in the FDP should be roughly balanced above and below the  $H_{60}$  line (1,480 m);
- the total area of proposed development in the FDP should be roughly balanced between north and south aspects;
- with respect to harvest timing, harvesting should not be concentrated near any one particular elevation at any one particular time, unless it is below the  $H_{60}$  elevation for the watershed (1,480 m); and,
- if ECAs approach the thresholds noted-above, the possible hydrologic effects should be evaluated to re-assess the recommended ECA thresholds.

The following additional operational recommendations provided by Summit (1998a) will also be met if Best Management Practices are followed during implementation of the plan:

- a contingency plan covering water supply interruptions should be developed, consistent with the Domestic Watershed Guidelines (Kootenay Inter-Agency Management Committee, 1997);
- effective communication should be maintained with field personnel; and
- field personnel should be effectively supervised during road and forest development, to ensure that water and sediment management recommendations are followed.

### 3.2 WINLAW CREEK

The current FDP for the Winlaw Operating Area (Amendment #9) is consistent with each of the planning recommendations of the current IWAP for Winlaw Creek (Henderson, 1999):

- ECA should not exceed 16% in the North Fork sub-basin, 20% in the Residual sub-basin and 20% overall;
- cutblocks should be located to avoid unstable terrain around gullies, avalanche paths and channels. Preference should be given to sites on gentle to moderate terrain;

- new road construction should be minimized by employing existing roads where possible. Roads should be deactivated after use if no longer needed; and,
- cutblocks should be spatially distributed over a variety of elevations and aspects to avoid synchronization of water delivery to channels (and potential increases in peak flows) as a result of snowmelt.

The following suggestions were also provided by Henderson (1999) as methods to reduce impacts to peak flow, water quality, and aquatic environments in Winlaw Creek:

- selective harvest systems should be employed that result in minimal canopy structure changes (i.e., high basal area retention), or use strip or patch cut systems that affect small changes to the snowmelt rate (e.g. openings equal to or less than 3 tree heights on flat or south facing slopes);
- blocks should be located below the H<sub>60</sub> elevation line to minimize the area of harvest contributing to snowmelt during the spring freshet;
- low impact harvest methods are preferred such as winter or horse logging;
- riparian shade prescriptions should be developed around fish-bearing reaches, particularly in the lower 2.0 km of the Winlaw Creek mainstem.

BC Timber Sales should consider this advice for this and future FDPs.

### **3.3 PEDRO CREEK**

No development-related recommendations were provided in the current IWAP (Summit, 1998b). However, an overall unweighted ECA level of 18.5% in 1998 was deemed to be of low risk to the hydrologic regime. Currently, the overall weighted ECA for Pedro Creek is 17.9%. Proposed development planned in the current FDP will increase the overall weighted ECA to 25.9%. Although unweighted and weighted ECAs can not be directly compared it is likely that the unweighted ECA of 18.5% in 1998 and the projected weighted ECA of 25.9% are consistent in regards to their impact on the hydrologic regime of Pedro Creek.

#### **4.0 HYDROLOGIC IMPACTS OF HARVESTING BEETLE-INFESTED TREES**

##### **4.1 HYDROLOGIC EFFECTS OF BEETLE KILL**

Little research has been conducted on the effects of insect infestations on water yield. However, the research that has been done indicates effects similar to those experienced after clearcutting: increases in annual water yield, increases in low flows in late summer and fall, and variable changes in peak flows. A bark beetle epidemic in the 1940's in Colorado caused average increases of about 25% in annual water yield in two study watersheds in the 25 years following the outbreak. Low flows also increased in both watersheds, but peak flows increased in one watershed and remained the same in the other. Differences between the two infested watersheds were found to be related largely to exposure. A mountain pine beetle epidemic in Montana in the mid-1970's resulted in a 15% increase in annual water yield, a 10% increase in low flows, a two-week advancement in the spring runoff, but little change in peak flows. These changes result from reduced evapotranspiration losses, as well as alteration of winter snow accumulation and melt processes in winter and spring.

Typically, a stand is not 100% affected by a beetle attack, and the resulting tree mortality is progressive, rather than instantaneous. Nevertheless, tree mortality and subsequent needle drop are responsible for the observed hydrologic effects: dead trees do not draw water from the soil and transpire it, defoliated tree crowns do not trap snow in winter, and the lack of leaves allows sunlight to easily penetrate in spring and melt snow earlier than in the adjacent forest. In general, an increase in water yield will persist as long as the rate of new trees being killed is higher than the rate dead trees are replaced. The effects have been hypothesized in the research literature to be similar to those experienced in a clearcut, which makes sense from a process point-of-view.

##### **4.2 POSSIBLE DIFFERENCES BETWEEN HARVESTING AND NOT HARVESTING A BEETLE-KILLED STAND**

To our knowledge, there has not been a specific experiment that compared the hydrologic effects of harvesting with not harvesting a beetle-killed stand. Because the post-infestation

effects are similar to those associated with a clearcut (whether harvesting occurs or not), the differences in the immediate post-infestation stage are likely not very large. However, we speculate that regeneration of a beetle-killed stand might be more rapid and effective if the site was harvested and then planted than if it was not harvested.

## **5.0 RISK ANALYSIS OF CURRENT FDP**

### **5.1 INTRODUCTION**

This section summarizes the risk analysis of the current FDP (Amendment #9) for the Winlaw Operating Area. The analysis is based on an office-based assessment of the FDP and information provided in the current watershed assessment (IWAP) reports. No field work has been performed in the completion of the analysis.

The types of risk associated with future development as summarized in this section are those associated with sediment delivery, peak flow regime, channel stability, and riparian function. In this section, these risks are evaluated using a consistent risk analysis framework (Section 5.2), and the results are conveniently presented in one of three risk categories (low, moderate, and high). The risk analysis is based on the current conditions in the watershed (as reported in the IWAPs and FDPs) and the development proposed in the FDP. The analysis is limited only to those sub-basins where development is proposed and locations downstream of these sub-basins.

### **5.2 RISK ANALYSIS FRAMEWORK**

As outlined in Wise et al. (2004), risk is often defined either qualitatively or quantitatively as the product of probability and consequence. Risk analysis involves determining the probability of occurrence of a specific event (e.g., landslide) and that event being a hazard to and affecting the specific element, and may involve estimates of the expected damage effects on the element at risk and consideration of the element's worth (Wise et al., 2004). As presented in Wise et al. (2004), the general risk equation can be summarized as:

$$R(S) = P(H) \times [P(S:H) \times P(T:S)] \times V(L:T) \quad \dots[\text{Equation 5.1}]$$

where:

**R(S)** = Specific risk to a specific element from a specific event (e.g., landslide).

**P(H)** = **P(Hazardous Event)** = probability of occurrence of a specific event and that event being a hazard to a specific element.

**[P(S:H) x P(T:S)]** = probability of the specific event reaching or otherwise affecting the specific element, where:

**P(S:H)** = probability of a spatial effect of the specific event on the specific element if the event occurs (e.g., the probability of the specific landslide reaching or otherwise affecting the specific element at risk).

**P(T:S)** = probability of temporal effect of the specific event on the specific element, given a spatial effect (e.g., the probability of the specific element occupying that location when the landslide occurs).

**V(L:T)** = vulnerability of the element, given a temporal effect. This accounts for the probability of loss of life or the proportion of loss, or damage to, property, the environment or other things of value.

In the context of this assessment, a Partial Risk Analysis approach was adopted. Partial Risk Analysis considers the effects of a specific hazard on a specific element, but it does not explicitly evaluate the vulnerability of the element **[V(L:T)]**. Such an evaluation is beyond the scope of this assessment, and requires obtaining specific information on the elements at risk (e.g., water quality, fisheries). Therefore, we have conservatively assumed that **V(L:T)** = 1, meaning that if an element is affected by an event, total loss will occur. The Partial Risk Analysis is summarized by Equation 5.2.

$$P(HA) = P(H) \times [P(S:H) \times P(T:S)] \quad \dots[\text{Equation 5.2}]$$

where: **P(HA) = P(Hazardous and Affecting Event)** = probability of occurrence of a specific hazardous event (e.g., landslide) and that event affecting a specific element.

For a stationary specific element at risk,  $P(T:S) = 1$ , therefore  $[P(S:H) \times P(T:S)] = P(S:H)$ . If it is certain a specific event will reach or affect a stationary specific element at risk, then  $[P(S:H) \times P(T:S)] = 1$ , and Equation 5.2 is reduced to **P(HA) = P(H)**. In this case, Equation 5.1 is also reduced to **R(S) = P(HA) = P(H)**. However, in the case where there is some uncertainty that a specific event will reach or affect a specific stationary element at risk,  $P(S:H) < 1$ . Therefore Equation 5.2 is reduced to:

$$R(S) = P(HA) = P(H) \times P(S:H) \quad \dots[\text{Equation 5.3}]$$

Since all elements at risk in this study are associated with the stream network (which is stationary), we have assumed throughout the risk analysis that  $P(T:S) = 1$ . Therefore, **P(HA)** and **R(S)** were evaluated based on Equation 5.3 and assigned qualitative ratings that vary depending on the element at risk. The definitions and ratings for **P(H)** and **P(S:H)** are defined by category (sediment delivery, peak flows, channel stability, and riparian function) and are presented with explicit reference to the framework provided by Equation 5.3.

### 5.3 SEDIMENT DELIVERY

The risk to water quality and/or fish habitat from sediment delivery is based on the probability of sediment reaching the stream network as a result of future forest development (i.e., harvesting and road construction). The two principal sources of mobile sediment include: 1) point sediment sources (i.e., landslides) and 2) non-point sediment sources (i.e., surface erosion, particularly from roads).

### 5.3.1 Point Sediment Sources

With respect to point sediment sources (i.e., landslides) the element at risk is the stream network, and in particular water quality and/or fish habitat. Equation 5.3 provides the framework for assessing the risk of point sediment sources to the stream network. In the case of point sediment sources, P(H) is based on the potential slide characteristics (e.g., size or magnitude and level or frequency of activity) while P(S:H) is based on the likely degree of coupling between the slide path and the stream network. P(H) was determined using Level C terrain stability mapping (presented on the FDP Amendment #9 map) and was rated according to Table 5.1, which is based on the estimated annual probability of an event occurring and the estimated magnitude of the event. P(S:H), which describes the degree of coupling, was rated according to Table 5.2. It should be noted that both P(H) and P(S:H) have been estimated in the office based solely on information provided in the current FDP, IWAPs and available terrain stability assessments, and have not been field confirmed. The matrix used to rate P(HA), which is the combined probability of an event (e.g., landslide) occurring and that event reaching and affecting the stream network, is presented in Table 5.3. A summary of the risk assessment for point sediment sources is presented in Table 5.4.

Table 5.1 Rating table for P(H) associated with risk of sediment delivery from future development-related point sediment sources (i.e., landslides).

| Estimated frequency                                                                                                                          | Estimated magnitude                      |                                                 |                                       |
|----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-------------------------------------------------|---------------------------------------|
|                                                                                                                                              | High<br>Slide area >1,500 m <sup>2</sup> | Moderate<br>Slide area 500-1,500 m <sup>2</sup> | Low<br>Slide area <500 m <sup>2</sup> |
| <b>High</b><br>Annual probability: >1/100 per annum<br>[Likelihood of an event within 20 years is probable (64%)]                            | High                                     | Moderate                                        | Low                                   |
| <b>Moderate</b><br>Annual probability: 1/500 to 1/100 per annum<br>[Likelihood of an event within 20 years is not likely but possible (18%)] | Moderate                                 | Moderate                                        | Low                                   |
| <b>Low</b><br>Annual probability: <1/500 per annum<br>[Likelihood of an event within 20 years is remote (4%)]                                | Low                                      | Low                                             | Low                                   |

Modified from MOF (2002).

Table 5.2 Rating table for **P(S:H)** associated with the risk of sediment delivery from point sediment sources (i.e., landslides) associated with future forest development.

| <b>P(S:H) Rating</b> | <b>Description</b>                                                                                                                               |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| High (H)             | Sediment source is coupled with the stream network and is likely to deliver sediment to the stream network.                                      |
| Moderate (M)         | Sediment source is partially coupled with the stream network leading to deposition of most of the sediment prior to reaching the stream network. |
| Low (L)              | Sediment source is not coupled with the stream network and is not likely to deliver sediment to the stream network.                              |

Table 5.3 Rating matrix for **P(HA)** associated with the risk of sediment delivery from point sediment sources associated with future forest development.

| <b>P(H) Rating</b>  | <b>P(S:H) Rating</b> |                     |                |
|---------------------|----------------------|---------------------|----------------|
|                     | <b>High (H)</b>      | <b>Moderate (M)</b> | <b>Low (L)</b> |
| <b>High (H)</b>     | High                 | Moderate            | Low            |
| <b>Moderate (M)</b> | Moderate             | Moderate            | Low            |
| <b>Low (L)</b>      | Low                  | Low                 | Low            |

Note: The ratings for **P(HA)** assume **P(T:S) = 1**.

Table 5.4 Risk assessment of point sediment sources associated with future forest development.

| WATERSHED    | SUB-BASIN | PROPOSED DEVELOPMENT | P(H) | P(S:H) | P(HA) = R(S)<br>(i.e., risk of triggering a landslide that affects water quality and/or fish habitat) | DISCUSSION                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------|-----------|----------------------|------|--------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trozzo Creek | Residual  | TSL #A59996-13       | M    | M      | Moderate                                                                                              | Based on BCTS (2004) a portion of this proposed block and the area downslope have been classified as potentially unstable or unstable terrain. As a result the proposed block and the downslope terrain should be field checked prior to development to further assess the risk of a triggering a landslide that may couple with the creek.                                                                                                                                       |
| Trozzo Creek | Residual  | TSL #A59997          | L    | L      | Low                                                                                                   | Based on BCTS (2004) the area where this block is proposed and the area downslope are not potentially unstable or unstable. In addition, according to Summit (1998a) no slope failures have occurred in this area in the past.                                                                                                                                                                                                                                                    |
| Trozzo Creek | Residual  | TSL #A59998          | M    | M      | Moderate                                                                                              | A portion of this proposed block is on potentially unstable or unstable terrain (BCTS, 2004). In addition, potentially unstable and unstable terrain and erodible soils characterize the area downslope of the proposed block. As a result, there is the potential for terrain stability issues. The proposed block and the downslope terrain should be field checked prior to development to further assess the risk of a triggering a landslide that may couple with the creek. |
| Trozzo Creek | Residual  | TSL #A60000          | M    | M      | Moderate                                                                                              | A portion of this proposed block is on potentially unstable or unstable terrain (BCTS, 2004). In addition, potentially unstable and unstable terrain and erodible soils characterize the area downslope of the proposed block. As a result, there is the potential for terrain stability issues. The proposed block and the downslope terrain should be field checked prior to development to further assess the risk of a triggering a landslide that may couple with the creek. |

Table 5.4 cont'd.

| <b>WATERSHED</b> | <b>SUB-BASIN</b> | <b>PROPOSED DEVELOPMENT</b> | <b>P(H)</b> | <b>P(S:H)</b> | <b>P(HA) = R(S)</b><br>(i.e., risk of triggering a landslide that affects water quality and/or fish habitat) | <b>DISCUSSION</b>                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------|------------------|-----------------------------|-------------|---------------|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trozzo Creek     | Residual         | TSL #A60001                 | <b>M</b>    | <b>L</b>      | <b>Low</b>                                                                                                   | The proposed location of this block is not on potentially unstable or unstable terrain (Henderson, 1999; BCTS, 2004). This proposed block was judged to have a very low to low hazard of slope instability within the proposed harvesting area and a moderate hazard rating in regards to downslope instability (Sitkum, 2004a). Riparian reserves are planned for shallow depressions and streams (Sitkum, 2004a).                                             |
| Trozzo Creek     | Residual         | Road WIR-01                 | <b>L</b>    | <b>L</b>      | <b>Low</b>                                                                                                   | The proposed location of this road and the area directly downslope are not on potentially unstable or unstable terrain (BCTS, 2004). This road does not cross any significant tributary streams.                                                                                                                                                                                                                                                                |
| Trozzo Creek     | Residual         | Road WIR-02                 | <b>L</b>    | <b>L</b>      | <b>Low</b>                                                                                                   | With the exception of where this road traverses through proposed block A59996-13, A60000, and A59998, this road is not on potentially unstable or unstable terrain (BCTS, 2004). Two creek crossings are proposed. There are no foreseeable issues assuming the road and crossings are constructed following Best Management Practices.                                                                                                                         |
| Winlaw Creek     | North Tributary  | TSL #A60001                 | <b>H</b>    | <b>L</b>      | <b>Low</b>                                                                                                   | The proposed location of this block is not on potentially unstable or unstable terrain (Henderson, 1999; BCTS, 2004). This proposed block was judged to have a very low to low hazard of slope instability within the proposed harvesting area (Sitkum, 2004a). However, the hazard for downslope instability is considered moderate to high. It should be noted that this hazard rating also applies to existing (pre-development) conditions (Sitkum, 2004a). |
| Winlaw Creek     | North Tributary  | Road WIR-01                 | <b>L</b>    | <b>L</b>      | <b>Low</b>                                                                                                   | The proposed location of this road is not on potentially unstable or unstable terrain (Henderson, 1999; BCTS, 2004).                                                                                                                                                                                                                                                                                                                                            |
| Winlaw Creek     | North Tributary  | Road WIR-02                 | <b>L</b>    | <b>L</b>      | <b>Low</b>                                                                                                   | The proposed location of this road is not on potentially unstable or unstable terrain (Henderson, 1999; BCTS, 2004).                                                                                                                                                                                                                                                                                                                                            |

Table 5.4 cont'd.

| WATERSHED    | SUB-BASIN | PROPOSED DEVELOPMENT | P(H) | P(S:H) | P(HA) = R(S)<br>(i.e., risk of triggering a landslide that affects water quality and/or fish habitat) | DISCUSSION                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------|-----------|----------------------|------|--------|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Winlaw Creek | Residual  | TSL #A74334-1        | M    | L      | Low                                                                                                   | The proposed location of this block is not on potentially unstable or unstable terrain (Henderson, 1999; BCTS, 2004). This proposed block was judged to have a very low to low hazard of slope instability within the proposed harvesting area and a low to moderate hazard rating for downslope terrain instability (Sitkum, 2004b). Riparian reserves are planned for shallow depressions and streams (Sitkum, 2004b). |
| Winlaw Creek | Residual  | TSL #A74334-2        | M    | L      | Low                                                                                                   | The proposed location of this cutblock is not on potentially unstable or unstable terrain (Henderson, 1999; BCTS, 2004). This proposed block was judged to have a very low to low hazard of slope instability within the proposed harvesting area and a moderate hazard rating in regards to downslope instability (Sitkum, 2004b). Riparian reserves are planned for shallow depressions and streams (Sitkum, 2004b).   |
| Winlaw Creek | Residual  | Road WIR-06          | L    | L      | Low                                                                                                   | The proposed location of this road and the area downslope are not on potentially unstable or unstable terrain (Henderson, 1999; BCTS, 2004).                                                                                                                                                                                                                                                                             |
| Pedro Creek  | Residual  | TSL #A74334-1        | L    | L      | Low                                                                                                   | The proposed location of this block and the area directly downslope is not on potentially unstable or unstable terrain (BCTS, 2004).                                                                                                                                                                                                                                                                                     |
| Pedro Creek  | Residual  | TSL #A74334-2        | M    | L      | Low                                                                                                   | The proposed location of this cutblock is not on potentially unstable or unstable terrain (Henderson, 1999; BCTS, 2004). This proposed block was judged to have a very low to low hazard of slope instability within the proposed harvesting area and a moderate hazard rating in regards to downslope instability (Sitkum, 2004b). Riparian reserves are planned for shallow depressions and streams (Sitkum, 2004b).   |
| Pedro Creek  | Residual  | Road WIR-03          | L    | L      | Low                                                                                                   | The proposed location of this road is not on potentially unstable or unstable terrain (BCTS, 2004). Three creek crossings are proposed. There are no foreseeable issues assuming the road and crossings are constructed following Best Management Practices.                                                                                                                                                             |

Table 5.4 cont'd.

| WATERSHED       | SUB-BASIN | PROPOSED DEVELOPMENT | P(H) | P(S:H) | P(HA) = R(S)<br>(i.e., risk of triggering a landslide that affects water quality and/or fish habitat) | DISCUSSION                                                                                                                                                                                                          |
|-----------------|-----------|----------------------|------|--------|-------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pedro Creek     | Residual  | Road WIR-05          | L    | L      | Low                                                                                                   | The proposed location of this road is not on potentially unstable or unstable terrain (BCTS, 2004). No creek crossings are proposed for this road.                                                                  |
| Pedro Creek     | Residual  | Road WIR-06          | L    | L      | Low                                                                                                   | The proposed location of this road is not on potentially unstable or unstable terrain (BCTS, 2004). One creek crossing is proposed for this road.                                                                   |
| Pedro Face Unit |           | TSL #A74334-2        | L    | L      | Low                                                                                                   | The proposed location of this block and the area downslope are not on potentially unstable or unstable terrain (BCTS, 2004). The nearest mapped stream in the drainage area is more than 1 km downslope.            |
| Pedro Face Unit |           | Road WIR-03          | L    | L      | Low                                                                                                   | The proposed location of this road is not on potentially unstable or unstable terrain (BCTS, 2004). No creek crossings are proposed for this road.                                                                  |
| Dumont Creek    |           | TSL #A60001          | L    | L      | Low                                                                                                   | The proposed location of this block and the area downslope are not on potentially unstable or unstable terrain (BCTS, 2004). The nearest stream in the drainage area of this block is several kilometers downslope. |
| Dumont Creek    |           | Road WIR-01          | L    | L      | Low                                                                                                   | The proposed location of this road is not on potentially unstable or unstable terrain (BCTS, 2004). No creek crossings are proposed for this road.                                                                  |
| Dumont Creek    |           | Road WIR-02          | L    | L      | Low                                                                                                   | The proposed location of this road is not on potentially unstable or unstable terrain (BCTS, 2004). A 500 m to 1000 m vegetated buffer separates it from the nearest stream.                                        |

Notes:

L = Low

M = Moderate

H = High

### 5.3.2 Non-point Sediment Sources

With respect to non-point sediment sources, and roads in particular, the element at risk is the stream network, and specifically water quality and/or fish habitat. Equation 5.3 presents the framework for assessing the risk of roads to the stream network. In the case of roads, **P(H)** is based on the potential for road surface erosion (which depends on surficial materials and road characteristics), while **P(S:H)** is based on the potential for delivery of sediment from the road to the stream network. **P(H)** is rated according to Table 5.5, which is based on the estimated annual sediment production from roads [as outlined in MOF and MELP (1999)]. **P(S:H)** is rated according to Table 5.6, which is adopted from MOF and MELP (1999). The rating for **P(HA)**, which is the combined probability of erosion potential and delivery potential to the stream network, is based on the matrix presented in Table 5.7.

Assuming that all proposed roads will be constructed following Best Management Practices (BMPs) tailored to the terrain and drainage conditions, **P(H)** will be rated low. Therefore, **P(HA)** and ultimately the risk of sediment delivery from all proposed roads are rated as low.

Table 5.5 Rating table for **P(H)** associated with the risk of sediment production from roads.

| <b>P(H)<br/>Rating</b> | <b>Sediment<br/>production class</b> | <b>Annual sediment production:<br/>range (m<sup>3</sup>/km of road length)</b> | <b>Road description</b>                                                                |
|------------------------|--------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| High                   | 4-6                                  | >30                                                                            | Severe erosion, gullyng, and/or total washout; access generally difficult with a 4x4   |
| Moderate               | 3                                    | 3 to 30                                                                        | Moderate erosion (typical of erodible materials, average maintenance, high use roads). |
| Low                    | 1-2                                  | <3                                                                             | Light erosion (typical of well armored low-use roads).                                 |

Modified from MOF and MELP (1999).

Table 5.6 Rating table for **P(S:H)** associated with the risk of sediment delivery from roads.

| <b>P(S:H) Rating</b> | <b>Sediment delivery class</b> | <b>Description</b>                                                                                                                                                                                                                                                                                                               |
|----------------------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| High                 | 3-4                            | High level of sediment delivery. Sediment delivered either directly or intermittently to the stream network via either or both ditch drainage or surface runoff routes. Low gradients and intermittent nature of the connecting drainage routes potentially lead to partial deposition of the sediment originating on the roads. |
| Moderate             | 2                              | Moderate level of sediment delivery. Sediment delivery partially disconnected from the stream network. Disconnected by flat terrain and/or discontinuous drainage routes. Low gradients and discontinuous nature of the connecting drainage routes lead to deposition of most of the sediment originating on the roads.          |
| Low                  | 1                              | No or minimal delivery of sediment from roads to any stream system. Sediment commonly delivered to forest floor, with no surface runoff evident or expected during the wet season.                                                                                                                                               |

Adopted from MOF and MELP (1999).

Table 5.7 Rating matrix for **P(HA)** associated with the risk of sediment delivery from roads.

| <b>P(H) Rating</b>  | <b>P(S:H) Rating</b> |                     |                |
|---------------------|----------------------|---------------------|----------------|
|                     | <b>High (H)</b>      | <b>Moderate (M)</b> | <b>Low (L)</b> |
| <b>High (H)</b>     | High                 | Moderate            | Low            |
| <b>Moderate (M)</b> | Moderate             | Moderate            | Low            |
| <b>Low (L)</b>      | Low                  | Low                 | Low            |

Note: The ratings for **P(HA)** assume **P(T:S) = 1**.

## 5.4

### PEAK FLOWS

This section summarizes the risk of future forest development on the peak flow regime, which is relevant because peak flows can alter channels and potentially impact water system infrastructure. Equation 5.3 provides the framework for assessing the risk of forest development on the peak flow regime. In the case of peak flows, **P(H)** is associated with the level of forest development (i.e., ECAs), while **P(S:H)** is associated with the watershed routing efficiency (see Table 5.9). **P(H)** was rated based on current overall ECA according to Table 5.8. The ECA ranges associated with the ratings in Table 5.8 are based on the recommendations in the current IWAPs and watershed assessment experience throughout the interior of B.C., particularly within the Kootenays. **P(S:H)**, which is based on the watershed routing efficiency, is rated according to the watershed characteristics presented in Table 5.9. The rating for **P(HA)**, which is the combined probability of ECA-related effects and watershed routing efficiency, is based on the matrix provided in Table 5.10. A summary of the risk to the peak flow regime is provided in Table 5.11.

Table 5.8 Rating table for **P(H)** associated with the risk of forest development to the peak flow regime.

| <b>P(H) Rating</b> | <b>Proposed Overall ECA</b> |
|--------------------|-----------------------------|
| High               | Greater than 40%            |
| Moderate           | Between 20% and 40%         |
| Low                | Less than 20%               |

Notes:

1. All ECA values are unweighted (i.e., ECAs above and below the  $H_{60}$  elevation are given equal weighting).

Table 5.9 Rating table for **P(S:H)** associated with the risk of forest development to the peak flow regime.

| <b>P(S:H) Rating<br/>(Watershed Routing Efficiency)</b> | <b>Watershed Characteristics</b>                                                                                         |                                                                                                                                                      |                                                                                                                                                                           |                                                                                                                                                                                                        |                                                                                                                  |
|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
|                                                         | <b>Lakes &amp; wetlands</b>                                                                                              | <b>Groundwater</b>                                                                                                                                   | <b>Stream network</b>                                                                                                                                                     | <b>Road network</b>                                                                                                                                                                                    | <b>Hillslopes</b>                                                                                                |
| High                                                    | Few or no lakes or wetlands, affecting less than 1% of the watershed                                                     | Soils are shallow and/or impermeable, with little loss of surface water to groundwater.                                                              | Extensive channel network, resulting in rapid routing of precipitation or snowmelt from headwaters to mainstem. Headwater channels are well defined and relatively large. | Roads extend the drainage network significantly, and cutbanks intercept subsurface flow, affecting a large part of the drainage basin (i.e. greater than 1/3 of the basin area).                       | Terrain is generally steep (>70%) to moderately steep (50-70%) slopes.                                           |
| Moderate                                                | Lakes and wetlands may be present, but only cause attenuation of peak flows from 1/4 to 1/2 of the watershed.            | Limited areas of deep, permeable soil. Significant losses of surface water to groundwater may affect parts of the watershed, but not all of it.      | Relatively extensive channel network with few/no discontinuities. Headwater Reaches are well defined.                                                                     | Road network extends the drainage network to a degree. Cutbanks intercepting subsurface flow are common, but the basin area upstream of such cutbanks is small (i.e. < 1/3 of the basin area).         | Terrain is generally moderate (27-49%), with local areas of moderately steep (50-70%) and gentle (6-26%) slopes. |
| Low                                                     | Frequent lakes and wetlands within the watershed, causing attenuation of peak flows from more than 1/2 of the watershed. | Soils may be permeable and deep, resulting in significant losses of surface water to groundwater, having much the same effect as lakes and wetlands. | The stream network may be discontinuous in places, with much of the headwaters unchannelized or drained by indistinct channels.                                           | Road network does not extend the drainage network significantly. High, long cutbanks are rare, and the basin area upstream of the existing cutbanks where subsurface flow is likely captured is small. | Terrain is generally gentle (6-26%) to moderate (27-49%) slopes.                                                 |

Table 5.10 Rating matrix for **P(HA)** associated with the risk of forest development to the peak flow regime.

| <b>P(H) Rating</b>  | <b>P(S:H) Rating</b> |                     |                |
|---------------------|----------------------|---------------------|----------------|
|                     | <b>High (H)</b>      | <b>Moderate (M)</b> | <b>Low (L)</b> |
| <b>High (H)</b>     | High                 | Moderate            | Low            |
| <b>Moderate (M)</b> | Moderate             | Moderate            | Low            |
| <b>Low (L)</b>      | Low                  | Low                 | Low            |

Note: The ratings for **P(HA)** assume **P(T:S) = 1**.

Table 5.11 Risk to the peak flow regime from forest development.

| <b>WATERSHED</b>  | <b>P(H)</b> | <b>P(S:H)</b>   | <b>P(HA)<br/>=<br/>R(S)</b><br>(i.e., risk of increased<br>peak flows due to<br>future development) | <b>DISCUSSION</b>                                                                                                                                                                                                                                                                                                                               |
|-------------------|-------------|-----------------|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trozzo (Residual) | <b>Low</b>  | <b>Moderate</b> | <b>Low</b>                                                                                          | ECA values are not relevant in a residual sub-basin. Harvesting in a residual should be considered in relation to the entire watershed, rather than the sub-basin itself.                                                                                                                                                                       |
| Trozzo (Overall)  | <b>Low</b>  | <b>Moderate</b> | <b>Low</b>                                                                                          | With an existing overall (weighted) ECA of 23.9% and a proposed overall (weighted) ECA of 24.3% the impact on the peak flow regime from proposed harvesting and road building is low. The total ECA from existing and proposed harvesting is not expected to result in noticeable changes to the peak flow regime of Trozzo Creek.              |
| Winlaw (Overall)  | <b>Low</b>  | <b>Moderate</b> | <b>Low</b>                                                                                          | With an existing overall (weighted) ECA of 5.3% and a proposed overall (weighted) ECA of 12.1% the impact on the peak flow regime from proposed harvesting and road building is low. The total ECA from existing and proposed harvesting is not expected to result in noticeable changes to the peak flow regime of Winlaw Creek.               |
| Pedro (Residual)  | <b>Low</b>  | <b>Moderate</b> | <b>Low</b>                                                                                          | ECA values are not relevant in a residual sub-basin. Harvesting in a residual should be considered in relation to the entire watershed, rather than the sub-basin itself.                                                                                                                                                                       |
| Pedro (Overall)   | <b>Low</b>  | <b>Moderate</b> | <b>Low</b>                                                                                          | With an existing overall (weighted) ECA of approximately 17.9% and a proposed overall (weighted) ECA of 25.9% the impact on the peak flow regime from proposed harvesting and road building is low. The total ECA from existing and proposed harvesting is not expected to result in noticeable changes to the peak flow regime of Pedro Creek. |

Notes:

1. The ECAs presented in the FDP are weighted values, whereas the ECA recommendations presented in the current IWAPs, which are used as a basis for the risk analysis are unweighted. A reassessment of ECA estimates is currently in progress. In the meantime we have assumed, based on the distribution of harvesting, that the weighted values are roughly 25% greater than the unweighted estimates.

## 5.5 CHANNEL STABILITY

In this section, the risk of proposed development in the watershed on channel stability is assessed. Equation 5.3 provides the framework for assessing the risk to channel stability. In the case of channel stability, **P(H)** is associated with the existing level and type of

development and disturbance in the watershed, while **P(S:H)** is associated with channel characteristics, particularly channel stability and sensitivity. **P(H)** was rated according to Table 5.12, and is based on **P(HA)** for peak flows (Section 5.2) (which takes into account ECAs and watershed routing efficiency), and evidence of direct disturbance to the channel or riparian zone (as reported in the current IWAPs). **P(S:H)** is rated according to Table 5.13 and combines the channel response potential (e.g., risk from indirect factors) and the risk of direct factors (e.g., existing channel stability and sensitivity to future disturbance). It is important to note that all estimates of P(H) and P(S:H) are based on an office review of the current IWAPs, and have not been field confirmed. The rating for **P(HA)**, which is the combined probability of indirect and direct impacts on the channel and the inherent stability and sensitivity of the channel to direct and indirect impacts, is based on the matrix provided in Table 5.14. A summary of the risk to channel stability is provided in Table 5.15.

Table 5.12 Rating table for **P(H)** associated with the risk to channel stability.

| <b>P(H) Rating</b> | <b>Description</b>                                                                                                                       |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| High               | <b>P(HA)</b> for peak flows rated as "high" and/or major anthropogenic impacts to the channel or riparian zone                           |
| Moderate           | <b>P(HA)</b> for peak flows rated as "moderate" and/or moderate anthropogenic impacts to the channel or riparian zone.                   |
| Low                | <b>P(HA)</b> for peak flows rated as "low" and/or little or no evidence of direct anthropogenic impacts to the channel or riparian zone. |

Table 5.13 Rating table for **P(S:H)** associated with the risk to channel stability.

| <b>P(S:H) Rating</b> | <b>Description</b>                                                                                                                        |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| High                 | Channel may be stable or unstable and has a high to extreme sensitivity to future direct disturbance; channel response potential is high. |
| Moderate             | Channel may be stable or unstable and is moderately sensitive to future direct disturbance; channel response potential is moderate.       |
| Low                  | Channel is currently stable and is not sensitive or only slightly sensitive to future disturbance; channel response potential is low.     |

Table 5.14 Rating matrix for **P(HA)** associated with the risk to channel stability.

| <b>P(H) Rating</b>  | <b>P(S:H) Rating</b> |                     |                |
|---------------------|----------------------|---------------------|----------------|
|                     | <b>High (H)</b>      | <b>Moderate (M)</b> | <b>Low (L)</b> |
| <b>High (H)</b>     | High                 | Moderate            | Low            |
| <b>Moderate (M)</b> | Moderate             | Moderate            | Low            |
| <b>Low (L)</b>      | Low                  | Low                 | Low            |

Note: The ratings for **P(HA)** assume **P(T:S) = 1**.

Table 5.15 Risk to channel stability from future forest development.

| <b>WATERSHED</b> | <b>P(H)</b> | <b>P(S:H)</b> | <b>P(HA)<br/>=<br/>R(S)</b><br>(i.e., risk of channel<br>instability due to<br>future<br>development) | <b>DISCUSSION</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------|-------------|---------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trozzo           | <b>L</b>    | <b>M</b>      | <b>Low</b>                                                                                            | Overall channel sensitivity is rated as low to moderate. Areas of moderate sensitivity are related to stretches where riparian harvesting has occurred, particularly along South Trozzo Creek and the north end of the main channel. However, overall the channel is stable, confined within an incised cobble, boulder, and bedrock channel. In addition, future ECA levels (<24.3%) are projected to remain below the maximum recommended ECA levels (25% to 30%) for the Trozzo Creek watershed (Summit, 1998a). As a result, no impacts to the peak flow regime are expected. |
| Winlaw           | <b>L</b>    | <b>M</b>      | <b>Low</b>                                                                                            | Overall, channel sensitivity is rated as moderate. Winlaw Creek is aggraded. However, the channel is confined within a deeply incised valley and bed and bank material is largely composed of cobbles, boulders and bedrock. In addition, future ECA levels (<12.1%) are projected to remain below the maximum recommended ECA levels (16% to 20%) for the Winlaw Creek watershed (Henderson, 1999). As a result, no impacts to the peak flow regime are expected.                                                                                                                |
| Pedro            | <b>L</b>    | <b>M</b>      | <b>Low</b>                                                                                            | Overall, channel sensitivity in the Pedro Creek sub-basin is slight to moderate. Areas of moderate to high sensitivity are confined to areas of riparian harvesting and the Pedro Creek alluvial fan. Overall, the channel is stable and confined within an incised cobble, boulder, and bedrock channel. In addition, future ECA levels are not projected to significantly increase above those reported in Summit (1998b). As a result, there is a low risk of impacts to the peak flow regime.                                                                                 |

Notes:

L = Low

M = Moderate

## 5.6

## RIPARIAN FUNCTION

In this section, the element at risk (from historic harvesting in the watershed) is riparian function. Equation 5.3 provides the framework for assessing the risk to riparian function from historic harvesting in the watershed. In the case of riparian function, **P(H)** is based on how the riparian harvesting will be conducted (e.g., by maintaining buffers or not), while **P(S:H)** is based on the proportion of stream length where riparian disturbance would occur. **P(H)** was rated according to Table 5.16, and is based on expected conditions of the riparian zone. These conditions reflect both the degree of historic riparian disturbance, the recovery since the historic disturbance, and the future development. **P(S:H)** is rated as outlined in Table 5.17 based on the proportion of channel length where the riparian zone is potentially disturbed. The rating for **P(HA)** is based on the matrix presented in Table 5.18. A summary of the risk to riparian function is provided in Table 5.19.

Table 5.16 Rating table for P(H) associated with the risk to riparian function.

| <b>P(H) Rating</b> | <b>Description of riparian conditions</b>                                             |
|--------------------|---------------------------------------------------------------------------------------|
| High               | Logged to bank; stabilizing vegetation present                                        |
| Moderate           | Partial buffer; intact banks                                                          |
| Low                | Extensive buffer; selective harvesting; natural conditions; no or minimal disturbance |

Table 5.17 Rating table for P(S:H) associated with the risk to riparian function.

| <b>P(S:H) Rating</b> | <b>Proportion of channel length with riparian disturbance</b> |
|----------------------|---------------------------------------------------------------|
| High                 | >50%                                                          |
| Moderate             | 20-50%                                                        |
| Low                  | <20%                                                          |

Table 5.18 Rating matrix for P(HA) associated with the risk to riparian function.

| <b>P(H) Rating</b> | <b>P(S:H) Rating</b> |                     |                |
|--------------------|----------------------|---------------------|----------------|
|                    | <b>High (H)</b>      | <b>Moderate (M)</b> | <b>Low (L)</b> |
| High (H)           | High                 | Moderate            | Low            |
| Moderate (M)       | Moderate             | Moderate            | Low            |
| Low (L)            | Low                  | Low                 | Low            |

Note: The ratings for P(HA) assume P(T:S) = 1.

Table 5.19 Risk to riparian function from proposed forest development.

| <b>WATERSHED</b>            | <b>P(H)</b> | <b>P(S:H)</b> | <b>P(HA)<br/>=<br/>R(S)</b><br>(i.e., risk of loss<br>of riparian<br>function as a<br>result of the<br>proposed<br>development) | <b>DISCUSSION</b>                                                                                                                                                                                                 |
|-----------------------------|-------------|---------------|---------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trozzo<br>(Residual)        | <b>Low</b>  | <b>Low</b>    | <b>Low</b>                                                                                                                      | Proposed harvesting is generally not planned within a riparian zone. Extensive wildlife reserves are planned for several tributaries draining the south side of the Trozzo Creek valley.                          |
| Trozzo (Overall)            | <b>Low</b>  | <b>Low</b>    | <b>Low</b>                                                                                                                      | Proposed development is generally not planned for riparian zones. Extensive wildlife reserves are planned for several tributaries draining the south side of the Trozzo Creek valley in the Residual sub-basin.   |
| Winlaw (North<br>Tributary) | <b>Low</b>  | <b>Low</b>    | <b>Low</b>                                                                                                                      | Proposed harvesting is generally not planned for riparian zones. However, it does appear on the FDP that a small section of unclassified stream does not include a buffer within proposed block A60001.           |
| Winlaw<br>(Overall)         | <b>Low</b>  | <b>Low</b>    | <b>Low</b>                                                                                                                      | Proposed harvesting is generally not planned for riparian zones. However, it does appear on the FDP that proposed blocks A60001 and A74334-2 do not include buffers along small sections of unclassified streams. |
| Pedro (Residual)            | <b>Low</b>  | <b>Low</b>    | <b>Low</b>                                                                                                                      | Proposed harvesting is generally not planned for riparian zones. However, it does appear on the FDP that proposed block A74334-2 do not include buffers along sections of three unclassified streams.             |
| Pedro (Overall)             | <b>Low</b>  | <b>Low</b>    | <b>Low</b>                                                                                                                      | Proposed harvesting is generally not planned for riparian zones. However, it does appear that proposed block A74334-2 does not include buffers along three small unclassified streams.                            |

## 6.0 POTENTIAL IMPACTS OF FDP ON WATER SUPPLY

This section summarizes the likelihood of impacts to domestic water supplies downstream of the proposed forest development. The risks to water quantity (i.e., insufficient flows), water quality (i.e., turbidity) and water intake infrastructure on both main streams and springs are considered.

## **6.1 TROZZO CREEK**

### **6.1.1 Location of Proposed Development**

Six points-of-diversion are identified along Trozzo Creek (on the FDP) in Appledale. Under the current FDP (Amendment #9), five cutblocks (TSL# A59996-13, #A59997, #59998, #A60000, #A60001) are proposed on the south side of Trozzo Creek roughly 2.5 to 5.0 km upstream of the uppermost point-of-diversion. Four are located adjacent to the creek and riparian buffers have been planned between these cutblocks and Trozzo Creek, with buffer width ranging from 150 m to 200 m. Riparian reserves are planned along tributaries adjacent to these four blocks. The fifth cutblock is located upslope along the watershed divide between Trozzo and Winlaw Creeks. No mapped watercourses are located within any of the five proposed cutblocks in Trozzo Creek. A proposed road (WIR-02) is planned to access the lower four proposed blocks from the southwest and traverse the blocks at approximately 1,100 m elevation. Road WIR-02 will cross two tributaries (with riparian reserves). Road WIR-01, which does not cross any mapped streams is planned to access the upper block.

### **6.1.2 Water Quantity**

The current overall ECA for Trozzo Creek is 23.9%<sup>2</sup>. The proposed forest development in the current FDP will increase the overall ECA by 0.4% up to 24.3%. As noted in Section 5.4, this level of ECA increase is not expected to significantly alter the hydrologic regime of Trozzo Creek.

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<sup>2</sup> As presented in Appendix 7.1.6 Table F of the Forest Development Plan Amendment #9. This estimate places increased weighting on cutblocks located above the  $H_{60}$  elevation. The result of this weighting procedure is an ECA estimate which is greater (or more conservative) than unweighted ECAs, which have been presented in the current IWAPs for the study area. A revised estimate of ECAs is currently in progress and will be provided under separate cover.

### **6.1.3 Water Quality**

Given that the proposed forest development poses a low risk of sediment delivery to the stream network (Section 5.3) and a low risk to channel stability, the risk to water quality (i.e., turbidity) as a result of the proposed development is low. This however, assumes that all roads and road crossings will be constructed using Best Management Practices tailored to the specific drainage and terrain conditions in the watershed, and that the riparian reserves are implemented as planned.

### **6.1.4 Water System Infrastructure**

No inspection has been conducted of the existing points-of-diversion to identify the current condition of this infrastructure. However, the increase in risk that the proposed forest development poses on infrastructure is low. This is based on a low risk to peak flows (Section 5.4), a low risk to channel stability (Section 5.5), and a low risk to water quality (Section 6.1.3) as a result of the proposed forest development.

## **6.2 WINLAW CREEK**

### **6.2.1 Location of Proposed Development**

Nineteen points-of-diversion are identified on the FDP along the mainstem of Winlaw Creek near the mouth. Under the current FDP (Amendment #9), one cutblock (TSL#A60001) is planned in the North Tributary sub-basin (along the watershed divide with Trozzo Creek), and two (TSL#A74334-1; TSL#A74334-2) are planned in the Residual sub-basin (along the watershed divide with Pedro Creek) in the southwest portion of the watershed. The cutblock in the North Tributary sub-basin is setback a minimum of 140 m from the North Tributary and will be accessed from the Trozzo Creek watershed by Road WIR-01 near an elevation of 1,600 m. A short length (approximately 80 m) of one tributary is located within the block boundary. The two cutblocks in the Residual sub-basin will be accessed by Roads WIR-03, WIR-05, and WIR-06, located almost entirely within the Pedro Creek watershed. The boundary of TSL#A74334-2 includes one tributary near the watershed divide, while TSL#A74334-1 does not include any mapped watercourses.

### **6.2.2 Water Quantity**

According to the FDP, the current overall weighted ECA for Winlaw Creek is 5.3%. The proposed forest development in the current FDP will increase the overall weighted ECA by 6.3% to 12.1%. The overall weighted ECA, however, remains well below the overall unweighted ECA of 20%, below which a detectable change in peak flows or annual water yield is not likely to be evident Henderson (1999). Furthermore, the proposed cutblocks are located on opposite sides of the watershed with varying aspect [as recommended by Henderson (1999)]. This serves to avoid synchronization of water delivery to channels from snowmelt. The risk to water quantity as a result of the proposed development is therefore low, as outlined in Section 5.4.

### **6.2.3 Water Quality**

Since the proposed forest development poses a low risk of sediment delivery to the stream network (Section 5.3) and a low risk to channel stability (Section 5.5), the risk to water quality (i.e., turbidity) as a result of the proposed development is low. This however, assumes that all roads and road crossings will be constructed using Best Management Practices tailored to the specific drainage and terrain conditions encountered in the field.

### **6.2.4 Water System Infrastructure**

No inspection has been conducted of the existing points-of-diversion to identify the current level of risk to infrastructure. However, the risk that the proposed forest development poses on infrastructure is low. This is based on the low risk to peak flows (Section 5.4), the low risk to channel stability (Section 5.5), and the low risk to water quality (Section 6.2.3) as a result of the proposed forest development.

## **6.3 PEDRO CREEK**

### **6.3.1 Location of Proposed Development**

Four points-of-diversion along the mainstem of Pedro Creek near the mouth are indicated on the FDP. Under the current FDP (Amendment #9) two cutblocks (TSL#A74334-1; TSL#A74334-2) are planned along the watershed divide with Winlaw Creek. Both cutblocks will be accessed by Roads WIR-03, WIR-05, and WIR-06, located at roughly an elevation of 1,450 m. TSL#A74334-2 crosses four streams, while TSL#A74334-1 on the southwest side of Donut Lake does not cross any mapped watercourses.

### **6.3.2 Water Quantity**

According to the FDP, the current overall weighted ECA for Pedro Creek is 17.9%. The proposed forest development in the current FDP will increase the overall weighted ECA by 8.0% to 25.9%. Although Summit (1998b) did not report a "red flag" ECA, they identified a low risk of hydrologic impacts under overall (unweighted) ECAs approaching 19%. Although weighted and unweighted ECA estimates cannot be directly compared it is likely based on the roughly even distribution of blocks above and below the  $H_{60}$  elevation that the weighted ECA of 25.9% is close to the unweighted value of 19% suggesting there likely will not be a detectable change in peak flows or annual water yield as a result of the proposed development. Nevertheless, current ECA estimates should be revised (this is in progress) in order to ensure a proper comparison.

### **6.3.3 Water Quality**

Since the proposed forest development poses a low risk of sediment delivery to the stream network (Section 5.3) and a low risk to channel stability (Section 5.5), the risk to water quality (i.e., turbidity) as a result of the proposed development is low. This however, assumes that all roads and road crossings will be constructed using Best Management Practices tailored to the specific drainage and terrain conditions.

#### **6.3.4 Water System Infrastructure**

No inspection has been conducted of the existing points-of-diversion to identify the current level of risk to infrastructure. However, the risk that the proposed forest development poses on infrastructure is low. This is based on the low risk to peak flows (Section 5.4), the low risk to channel stability (Section 5.5), and the low risk to water quality (Section 6.3.3) as a result of the proposed forest development.

### **6.4 PEDRO FACE UNIT**

#### **6.4.1 Location of Proposed Development**

Fifteen points-of-diversion are located within the Pedro Face Unit on the east side of the Slocan River between Pedro and Winlaw Creeks. Most of the points-of-diversion are located near the valley bottom and the source of each water intake appears to be springs or unmapped streams. A portion of TSL#A74334-2 (approximately 60 ha) and Road WIR-06 is proposed for the uppermost portion of the Pedro Face Unit, roughly 1 km upslope (and 650 m higher) than the uppermost point-of-diversion.

#### **6.4.2 Water Quantity**

According to the FDP, the ECA of the Pedro Face Unit is currently 0.0%. The portion of TSL#A74334-2 proposed within the face unit covers approximately 60 ha (or 11% of the total area of the face unit). Generally, this level of harvesting is not expected to noticeably affect the hydrologic regime of the face unit, particularly given that:

- the proposed block does not cross any prominent streams;
- the development is roughly 1 km from the intakes; and,
- the removal of dead (beetle-infested) trees is likely to have a negligible effect on peak flows (Section 4.0).

Assuming that natural drainage patterns are maintained during road construction (along WIR-03 and WIR-06) and harvesting, the risk to water quantity as a result of the proposed development is low.

### **6.4.3 Water Quality**

Since there are no mapped streams flowing across the proposed cutblock and road and the intakes are at least 1 km downslope of the proposed development, the risk to water quality (i.e., turbidity) as a result of the proposed development is low. Nevertheless, all roads and stream crossings (if any) should be constructed using Best Management Practices tailored to the specific drainage and terrain conditions encountered in the field, including maintenance of natural drainage patterns.

### **6.4.4 Water System Infrastructure**

No inspection has been conducted of the existing points-of-diversion to identify the current level of risk to infrastructure. However, since the proposed development is located well upslope and does not appear coupled to the domestic water sources by surface streams, the overall risk that the proposed forest development poses on infrastructure is low.

## **6.5 DUMONT CREEK**

### **6.5.1 Location of Proposed Development**

A relatively small portion of TSL#A60001 (approximately 10 ha) and 250 m length of road is proposed in the uppermost portion of the face unit that largely feeds Dumont Creek. Approximately 17 points-of-diversion are located downstream of the proposed development. Most of the points-of-diversion are located near the valley bottom along Dumont Creek, but some are also located on small tributary streams or springs. The nearest point-of-diversion is located 2.2 km downslope and 650 m lower in elevation than the proposed cutblock. No streams are mapped between the proposed cutblock and uppermost point-of-diversion.

### **6.5.2 Water Quantity**

The portion of TSL#A60001 proposed within the face unit covers approximately 10 ha and is not expected to noticeably affect the hydrologic regime of Dumont Creek or its tributaries. Assuming that natural drainage patterns are maintained during road construction and harvesting, the risk to water quantity as a result of the proposed development is low.

### **6.5.3 Water Quality**

Since there are no mapped streams flowing across the proposed cutblock and road, the risk to water quality (i.e., turbidity) as a result of the proposed development is low. Nevertheless, all roads and road crossings should be constructed using Best Management Practices tailored to the specific drainage and terrain conditions encountered in the field.

### **6.5.4 Water System Infrastructure**

No inspection has been conducted of the existing points-of-diversion to identify the current level of risk to infrastructure. However, since the proposed development is located well upslope and does not appear coupled to the domestic water sources by surface streams, the overall risk that the proposed forest development poses on infrastructure is low.

## **7.0 CONCLUSIONS AND RECOMMENDATIONS**

### **7.1 BEETLE KILL**

The scientific literature on the effects of widespread bark beetle infestations on forest hydrology was reviewed and summarized. From this we conclude the following:

- little research has been conducted on the effects of insect infestations on water yield;
- widespread beetle infestation is likely to result in effects similar to those experienced after clearcutting: increases in annual water yield, increases in low flows in late summer and fall, and variable changes in peak flows; and,

- there has not been an experiment that compares the hydrologic effects of harvesting with not harvesting a beetle-killed stand.

## 7.2 FDP REVIEW

The current FDP was reviewed with respect to its compliance with the recommendations for future development provided in the most recent IWAP reports on Trozzo Creek, Winlaw Creek, and Pedro Creek (Summit, 1998a; 1998b; Henderson, 1999). After an office review of the current FDP, current IWAP reports, and available terrain stability assessment reports, the following conclusions have been drawn:

- the current FDP for the Winlaw Operating Area (Amendment #9) is consistent with all recommendations of the current IWAPs;
- with the exception of proposed blocks TSL #A60000, #A59998, and #A59996-13 in the Trozzo Creek watershed, which present a moderate risk, all development approved and proposed under the current FDP presents a low risk of sediment delivery to streams;
- based on proposed development under the current FDP the risk to peak flows is low for Trozzo Creek, Winlaw Creek, and Pedro Creek;
- based on proposed development under the current FDP the risk to channel stability is low for Trozzo Creek, Winlaw Creek, and Pedro Creek;
- based on proposed development under the current FDP the risk to riparian function is low for Trozzo Creek, Winlaw Creek, and Pedro Creek;
- Overall, there is a low risk that water quality, water quantity, and water system infrastructure will be affected by the current FDP.

We recommend that terrain stability field assessments of proposed blocks TSL #A59998, A60000, and A59996-13 and the associated downslope terrain in the Trozzo Creek watershed be completed prior to development.

## 8.0

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